

## CLAIMS

*What is claimed is:*

1. A method of forming an isolation structure on an integrated circuit substrate, comprising:
  - 5 etching a trench in the integrated circuit substrate;
  - forming a lower dielectric layer in the trench, the lower dielectric layer partially filling the trench; and
  - 10 forming an upper dielectric layer in the trench over the lower dielectric layer to create an isolation structure;

wherein the upper dielectric layer has an HF etch rate that is approximately equal to or lower than that of Silicon dioxide, and the upper and lower dielectric layers together have an effective dielectric constant that is less than that of silicon dioxide.

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2. The method as recited in claim 1, further comprising:

prior to forming the lower dielectric layer, forming a trench liner that substantially conforms to the trench;

20 wherein forming a lower dielectric layer in the trench comprises forming the lower dielectric layer over the trench liner.

3. The method as recited in claim 2, wherein the trench liner comprises silicon dioxide.

5 4. The method as recited in claim 1, wherein the thickness of the upper dielectric layer is less than the thickness of the lower dielectric layer.

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10 5. The method as recited in claim 1, wherein the effective dielectric constant corresponds to at least one of horizontal and vertical capacitance associated with the isolation structure.

15 6. The method as recited in claim 1, wherein the dielectric constant of the upper layer is approximately 5.0.

7. The method as recited in claim 1, wherein the lower dielectric layer is Carbon doped silicon dioxide.

20 8. The method as recited in claim 7, wherein the Carbon doped silicon dioxide is SiOC.

9. The method as recited in claim 7, wherein forming a lower dielectric layer comprises:

5 depositing the Carbon doped silicon dioxide by a hydrogen-peroxide assisted process, Ozone assisted deposition or organic spin-on material.

10 10. The method as recited in claim 1, wherein the upper dielectric layer has a higher dielectric constant than the lower dielectric layer.

11. 11. The method as recited in claim 1, wherein the lower dielectric layer has a dielectric constant below 3.9.

12. 12. The method as recited in claim 1, wherein the lower dielectric 15 layer has a dielectric constant that is approximately 2.5.

13. 13. The method as recited in claim 1, wherein the upper dielectric layer is amorphous SiC or silicon dioxide.

20 14. 14. The method as recited in claim 13, wherein forming the upper dielectric layer comprises:

applying an alkylsilane base precursor with PECVD or an Ozone assisted technique to form the amorphous SiC.

5 15. The method as recited in claim 1, wherein the upper dielectric layer has a higher or equal etch resistance to wet HF etch.

10 16. The method as recited in claim 1, wherein the upper dielectric layer has an HF etch selectivity of between approximately 5:1 and approximately 30:1 to SiO<sub>2</sub>.

15 17. The method as recited in claim 1, further comprising:

ascertaining a thickness of the lower dielectric layer and a thickness of the upper dielectric layer to be formed from information indicating an effective dielectric constant corresponding to relative thicknesses of a lower dielectric material for the lower dielectric layer and an upper dielectric material for the upper dielectric layer.

20 18. The method as recited in claim 17, wherein the information is obtained from an equation or graph.

19. The method as recited in claim 17, wherein the information includes vertical and horizontal capacitances associated with the isolation structure.

5 20. The method as recited in claim 17, wherein ascertaining a thickness of the lower dielectric layer and a thickness of the upper dielectric layer to be formed comprises:

selecting the lower dielectric material and the upper dielectric material;

10 selecting the effective dielectric constant, the effective dielectric constant corresponding to thicknesses of both the lower dielectric material and the upper dielectric material; and

15 determining the thickness of the lower dielectric layer and the thickness of the upper dielectric layer from the information indicating an effective dielectric constant corresponding to thicknesses of both the lower dielectric material for the lower dielectric layer and the upper dielectric material for the upper dielectric layer.

21. The method as recited in claim 17, wherein ascertaining a thickness of the lower dielectric layer and a thickness of the upper dielectric layer to be formed comprises:

selecting the lower dielectric material and the upper dielectric material;

selecting a range of acceptable effective dielectric constants that correspond to thicknesses of both the lower dielectric material and the upper dielectric material; and

determining a range of acceptable thicknesses of both the lower dielectric layer and the upper dielectric layer from the range of acceptable dielectric constants using the information indicating an effective dielectric constant corresponding to thicknesses of both the lower dielectric material for the lower dielectric layer and the upper dielectric material for the upper dielectric layer.

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22. The method as recited in claim 1, further comprising:

determining a desired combined thickness of both the lower dielectric layer and the upper dielectric layer;

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selecting a thickness of a first layer of a group consisting of the lower dielectric layer and the upper dielectric layer; and

ascertaining a thickness of a second layer of the group consisting of the lower dielectric layer and the upper dielectric layer from both the thickness of the first layer and the desired combined thickness.

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23. The method as recited in claim 22, further comprising:

selecting a lower dielectric material for the lower dielectric layer and an upper dielectric material for the upper dielectric layer;

ascertaining the effective dielectric constant from information indicating the effective dielectric constant corresponding to thicknesses  
5 of both the lower dielectric material for the lower dielectric layer and the upper dielectric material for the upper dielectric layer; and

determining whether the effective dielectric constant is within a desired range of dielectric constants.

10 24. The method as recited in claim 23, the method further comprising:

repeating the steps of selecting the thickness of the first layer and ascertaining the thickness of the second layer when it is determined that the effective dielectric constant is not within the desired range of dielectric constants.

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25. The method as recited in claim 1, wherein the upper dielectric layer has an HF etch rate that is lower than that of the lower dielectric layer.

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26. A method of selecting a thickness of a lower dielectric layer and a thickness of an upper dielectric layer to be formed above the lower dielectric layer of a multi-layer isolation structure comprises:

selecting a lower dielectric material for the lower dielectric layer and an upper dielectric material for the upper dielectric layer;

selecting a range of one or more effective dielectric constants that correspond to thicknesses of both the lower dielectric material and the  
5 upper dielectric material; and

determining a range of one or more thicknesses of each of the lower dielectric layer and the upper dielectric layer from the range of acceptable dielectric constants using information indicating an effective dielectric constant corresponding to thicknesses of both the lower  
10 dielectric material for the lower dielectric layer and the upper dielectric material for the upper dielectric layer, thereby enabling the multi-layer isolation structure to be formed.

27. An isolation structure formed on an integrated circuit substrate,  
15 comprising:

a lower dielectric layer substantially conforming to a trench in the integrated circuit substrate such that the lower dielectric layer partially fills the trench; and

an upper dielectric layer over the lower dielectric layer, the upper  
20 dielectric layer having an HF etch rate that is approximately equal to or lower than that of Silicon dioxide, the upper dielectric layer and the lower dielectric layer together having an effective dielectric constant that is less than that of silicon dioxide.

28. The isolation structure as recited in claim 27, further comprising:

a trench liner that substantially conforms to the trench, the lower dielectric layer being formed over the trench liner.

5 29. The isolation structure as recited in claim 28, wherein the trench liner comprises silicon dioxide.

10 30. The isolation structure as recited in claim 27, wherein the thickness of the upper dielectric layer is less than the thickness of the lower dielectric layer.

31. The isolation structure as recited in claim 27, wherein the effective dielectric constant corresponds to at least one of horizontal and vertical capacitance associated with the isolation structure.

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32. The isolation structure as recited in claim 27, wherein the lower dielectric layer is Carbon doped silicon dioxide.

20 33. The isolation structure as recited in claim 32, wherein the Carbon doped silicon dioxide is SiOC.

34. The isolation structure as recited in claim 27, wherein the lower dielectric layer has a dielectric constant below 3.9.

35. The isolation structure as recited in claim 27, wherein the upper  
5 dielectric layer is amorphous SiC or silicon dioxide.

36. The isolation structure as recited in claim 27, wherein the upper dielectric layer has a higher or equal etch resistance to wet HF etch.

10 37. The isolation structure as recited in claim 27, wherein the upper dielectric layer has an HF etch selectivity of between approximately 5:1 and approximately 30:1 to SiO<sub>2</sub>.

15 38. The isolation structure as recited in claim 27, wherein a thickness of the lower dielectric layer and a thickness of the upper dielectric layer together correspond to the effective dielectric constant.

20 39. The isolation structure as recited in claim 27, wherein the lower dielectric layer is formed from a lower dielectric material and the upper dielectric layer is formed from an upper dielectric material, the effective dielectric constant corresponding to thicknesses of both the lower dielectric material and the upper dielectric material.

40. The isolation structure as recited in claim 27, wherein the upper dielectric layer has a higher HF etch resistance than the lower dielectric layer.